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AUTHOR	Hunt, Leslie; Karl, Rita
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ABSTRACT

This paper provides an account of the instructional design and development process used by a team of students enrolled in a graduate level course in distance education as the team members conceptualized and created two prototype World Wide Web-based instructional modules, aimed at grades 5 through 12, for the Lunar and Planetary Institute's Mars Millennium Web site and CD-ROM project to support the National Aeronautic and Space Administration's Jet Propulsion Laboratory. The paper is intended to serve as an instructional design blueprint for other curriculum designers and educators to use, should they encounter a similar need for interactive Web-based curriculum based on scientific theory and data, which incorporates a variety of emerging technologies, Internet tools, and innovative instructional strategies. (Author/MES)

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Design and Development of an Interactive Web-Based Curriculum in Support of the Space Science Education Initiative: Mars Millennium

Leslie Hunt
Instructional Technology Program
University of Houston - Clear Lake
United States
wlhunt@worldnet.att.net

G.H. Marks

Rita Karl
Lunar and Planetary Institute
NASA
United States
karl@lpi.usra.edu

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Abstract: This paper provides an account of the instructional design and development process used by a team of students enrolled in a graduate level course in Distance Education as the team members conceptualized and created two prototype web-based instructional modules for the Lunar and Planetary Institute's (LPI) Mars Millennium web site and CD-ROM project to support the National Aeronautic and Space Administration's (NASA) Jet Propulsion Laboratory (JPL). It is intended that this paper serve as an instructional design blueprint for other curriculum designers and educators to use, should they encounter a similar need for interactive web-based curriculum based on scientific theory and data, which incorporates a variety of emerging technologies, Internet tools, and innovative instructional strategies.

Introduction

The Mars Millennium Project, an official White House Millennium Council Youth Initiative, is a national art, science and technology initiative created to encourage students to design a community for 100 people arriving on Mars in the year 2030 (see http://www.mars2030.org/). Each educational team participating in the Mars Millennium Project has been giving the goal to design a livable life-sustaining community on Mars that is culturally and artistically rich. The Mars Millennium Project is spearheaded by the U.S. Department of Education, the National Aeronautics and Space Administration (NASA) and its Jet Propulsion Laboratory (JPL), the National Endowment for the Arts, and the J. Paul Getty Trust. NASA's Lunar and Planetary Institute (LPI) is contributing to the project by developing web-based curriculum for the Mars Millennium Project and piloting the curriculum in Houston-area schools, libraries, youth and arts centers (see http://www.lpi.usra.edu).

In support of LPI's goal to provide educators and students access to on-line interactive activities as a part of it's educational mission for NASA's Office of Space Science and the Mars Millennium White House Initiative, the Institute's education staff is working with graduate students in the University of Houston-Clear Lake's (UHCL) Instructional Technology (INST) Program to design and develop a series of on-line multimedia activities. Utilizing the scientific research, data, theories and expertise of the planetary scientists at the Lunar and Planetary Institute, two prototype interactive web-based instructional units have been developed focusing on the planet Mars. The units will be featured as part of the education programs available for K-12 educators and students accessing the LPI web page. The Mars curriculum will be targeted to students in middle and high school (grades 5-12) and will be presented as part of LPI's support of the White House Mars Millennium Initiative which challenges students to imagine a human colony on Mars in the year 2030. The web-based materials will be tested with the LPI gifted and talented 5th grade students who attend a weekly "Exploring the

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Planets" class and with educators at the LPI summer workshop, 'Liftoff 2000: Mars'.

This paper outlines the process used by the instructional design team as they began to systematically design and develop this web-based curriculum. The curriculum designers will explain how the team members used learner and context analysis data to guide them as they identified the most appropriate instructional theory to use as a basis for their curriculum development. The designers will illustrate how an instructional analysis of the subject matter impacted their selection of instructional strategies. And, the design team will describe their development of the web interface and page layout. It is intended that this paper will serve as an instructional design blueprint for other curriculum designers and educators to use, should they encounter a similar need for an interactive web-based curriculum, based on scientific theory and data, which incorporates a variety of emerging technologies, Internet tools, and innovative instructional strategies.

The Instructional Design Process

Given the fact that all members of the instructional design team had experience using the Dick and Carey model (Dick & Carey, 1996), the team agreed to base the project's instructional design process on these steps and processes as they created the curriculum. Although the UHCL designers were involved only with the design and development phases of the instructional design process, all decisions regarding instructional strategies were based on LPI instructional analysis data. A list of the process steps followed by the team are outlined in sequential order below:

- Review LPI data on Mars Millennium Project purpose statement and goals
- Review LPI data on LPI's preferences regarding instructional context
- Review LPI data on LPI's content analysis for specific modules of instruction
- Review LPI data on target learners
- Create instructional goals for each module of instruction
- Identify philosophical foundation upon which instruction will be based
- Break each module of instruction into requisite number of lessons
- Create instructional objectives for each lesson
- Select instructional strategies for each objective
- Design web interface for the curriculum
- Flow chart each module
- Storyboard each lesson
- Identify LPI digital resources to be used for each lesson
- Write lesson content and activities
- Import content, activities and digital images into the web interface
- Proof content and check links

The instructional design team consisted of a group of six instructional technology graduate students who were interested in providing a prototype distance education project for the Lunar and Planetary Institute's Mars Millennium web site and CD-ROM project. One of the members serves on the educational staff at LPI and secured approval for the team to undertake the assignment. This group member was also the team's contact for all LPI Mars Millennium resources, such as scientists (also referred to as subject matter experts), digital images, animation, logos, and instructional analysis data already compiled.

Under direction from the LPI staffer, the design team reviewed the current proposal for a curriculum design for the national program aimed at grade 5 through 12 that had already been developed by the LPI Education Staff. From this extensive listing of proposed curriculum, the team decided on two instructional modules: *Mars of the Mind* and *Ocean on Mars*. Two separate groups of three team members each were formed with each three-person subgroup assuming responsibility for one module. Although the subgroups would be creating instructional strategies and content independent of the main group, other decisions, such as the selection of the philosophical foundation for the curriculum and the web interface design would still be coordinated with all six team members to maintain alignment between the modules.

Analysis

LPI's Education Staff presented the UHCL instructional design team with instructional analysis information that was critical to the development of sound, systematically-design curriculum. This information included the purpose statement for LPI's Mars Millennium curriculum project, which is:

> "To create a curriculum that is suitable for use in 5-12th grade classrooms with the goal of impacting students and teachers at a national level through the Mars Millennium project, our gifted student program, Alpha, and through a variety of outreach endeavors, including Liftoff and Explore (National Educator Training Workshops) by addressing the following goals:
>
> - To address issues relating to the history of the planet Mars and it's current geologic condition through a series of Earth-Mars analogues, hands-on activities, modeling, 3-D imagery, and other presentation materials, and
>
> - To help support the teaching of the scientific issues facing mission planners designing robotic and manned exploration missions to Mars via a distance learning venue such as the web or CD-ROMs." (Karl & Clifford, 1999)

In addition, the Institute provided the following guidance regarding its preferences for the instructional context and content:

> - "We will develop a distance learning venue for the curriculum in order to reach students and teachers nationwide in the Mars Millennium project, by using a web-based format and CD-ROM format. This will include video interviews of a Mars scientist, graphics depicting the possible ocean on Mars, and animated sequences illustrating current missions to Mars that are searching for evidence of water (i.e. the Deep Space Microprobes). The site will also include ways to e-mail with Mars scientists (Ask-a-Mars-scientist), links to Mars activities, images, presentations, posters and resources.
>
> - We will prepare lessons and activities that will address the historical issues of Schiaparelli's 'seas on Mars' and Percival Lowell's 'canals on Mars', and how man's view of the red planet has changed with improvements in technology by using modeling and Earth analogues.
>
> - We will gather NASA (and other) materials suitable for including in this curriculum including, for example, the Surveyor '98 poster which illustrates Mars in the past with oceans and Mars in the present without running water (and also examples of chaotic terrain)." (Karl & Clifford, 1999)

And, lastly, a description of the target learners stated, "We will beta test the activities and materials developed with the pilot Mars Millennium sites this year in Houston and with the Alpha (gifted and talented) students (5th graders) here at the Institute. We will present the material to the teachers at next year's Liftoff 2000, which will focus on Mars, and to the librarians who participate in the Explore Program, Fun with Science." (Karl & Clifford, 1999)

Based on a review of this information, the instructional design team was able to construct goal statements for each of the instructional modules. The *Ocean on Mars* module goal became: "To present an integrated interactive site for distance education serving the Mars Millennium high school students by using chemistry, scientific theory and mission data in order to design new missions to Mars." And, the *Mars of the*

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Mind module goal translated into: "Gifted fifth and sixth grade students will hypothesize as to what Mars might look like in 2005 with improved technology. Students will accomplish this by navigating the Mars of the Mind web site to (1) review examples of well-known inventions and discoveries which hold a prominent place in history due to the way mankind's views of reality and truth were altered by them, (2) view historical pictures of Mars from different time periods and study the then available technologies used to form those pictures, (3) use this information to form opinions concerning the accuracy of technology and its effect on man's view of the universe at any given time, and (4) use these opinions to imagine what technology will be available five years from now and what man's view of Mars will be because of it."

With these instructional goals and the instructional analysis data from LPI before them, the team decided to use a constructivist approach as the philosophical foundation for their module and lesson designs. Designers of constructivist learning environments subscribe to instructional methods which provide students with experience in the knowledge construction process and appreciation for multiple perspectives, embed learning in realistic and relevant contexts, encourage ownership and voice in the learning process, embed learning in social experiences, encourage use of multiple modes of representation, and encourage self-awareness of the knowledge construction process (Wilson, 1996, pp. 11-12). Constructivism seemed an excellent approach given the exploration- and discovery-based theme of these instructional goals, the inquisitive nature of the gifted and talented students, and the web-based delivery method.

Design

Each instructional module was broken up into three lessons, with the first lesson supplying an introduction to the unit or some background information that students would need in order to proceed with the instruction. The second lessons provided the heart of the instruction where students engaged in web-based interactivities. Students were then asked to construct new meaning out of their experiences in the last lessons and provide some type of evidence of their new knowledge. Instructional objectives were then written for each of these lessons and are presented in Table 1.

	Instructional Objectives	
Lesson	***Mars of the Mind***	***Ocean on Mars***
1	Students will review examples of well-known inventions and discoveries, which hold a prominent place in history due to the way mankind's views of reality and truth were altered by them.	Students will learn how scientists use mission data in their research in order to develop theories, which will then influence future mission designs in order to help determine the validity of their work.
2	Students will view historical pictures of Mars from different time periods and study the then available technologies used to form those pictures.	Students will learn how the chemistry of Mars drives the future exploration of the planet in terms of sustaining a human presence on Mars.
3	Students will use this information to form opinions concerning the accuracy of technology and its effect on man's view of the universe at any given time and imagine what technology will be available five years from now and what man's view of Mars will be because of it.	Students will develop a rudimentary knowledge of the chemical processes needed to sustain life on Mars using in situ resources.

Table 1: Instructional Objectives for *Mars of the Mind* and *Ocean on Mars*

With the instructional objectives in hand, the design team began to formulate the instructional strategies, which would ensure that learning occurs as students move through the modules. The *Ocean on Mars* group decided to present the scientist's theory that an ocean may have existed on Mars and to provide students with a glimpse of a current mission sent to find this water. Students would engage in an on-line interactive chemistry lab in order to understand what an impact the presence of water on Mars would have for human exploration and colonization. Students would then be encouraged to be a part of this developing exploration program by designing a mission to be published on the site and by interacting with scientists through e-mail.

The *Mars of the Mind* group began by providing students with an example of how the evolution of a different type of technology (other than telescopes) changed man's view of reality and truth throughout history. Students would be taken on a web voyage to explore how the technological improvements in the telescope changed man's view of Mars. Students would then be challenged to hypothesize about the new technology that may be available to them in the year 2030 that would facilitate establishment of a colony on Mars and then write an essay or draw a picture of this technology for an on-line student gallery.

Now that the design was complete, the team set out to develop the web-based modules.

Development

The curriculum interface consists of the module logos and the navigation bars. Module logos, found on each site's home page, were based on the NASA mission patch for the Mars Surveyor '98 mission. PhotoShop was used to create the majority of the logo and then each subgroup customized the three points of the triangle to correspond to the titles of each subgroup's three lessons. After imposing an image map over the customized logos, "launching pads" were established for the students to access the lessons. The navigation bars were constructed in a similar fashion. Generic "Home" and "Lesson" buttons were established and then customized for each module.

Each subgroup flowcharted its sites and then drew up storyboards for each lesson. The next step, identifying and selecting digital enhancements for each web page, was easy given the vast repository of LPI resources. LPI is one of the world's largest Regional Planetary Image Facilities (RPIFs) which catalogues and stores all of the planetary mission imagery on-site, much of it in digital formats. Narrative content was then written and instructional activities detailed.

The *Ocean on Mars* web pages were authored with Dreamweaver, while the *Mars of the Mind* web pages were created with HTML. The team believed that it was important to demonstrate that instructionally sound web-based instruction could be created using both high end and basic web authoring tools.

The result of this work on both web sites can be found in prototype format at http://www.ghg.net/ritakarl/MOMMain.html (*Mars of the Mind*) and http://www.ghg.net/ritakarl/main.html (*Ocean on Mars*).

Assessment

If accepted by the Lunar and Planetary Institute as a prototype web-site, testing will occur via the Institute's involvement with the fourteen Houston beta-testing sites for the Mars Millennium project. Fourteen at-risk, underserved, and low socio-economic schools and youth groups in Houston are piloting the White House Youth Initiative over the course of the next school year. In addition, the Lunar and Planetary Institute teaches a 5th grade gifted and talented program for the Clear Creek Independent School District called 'Exploring the Planets'. Both of these groups would test the actual curriculum and be asked to evaluate the students' experiences. Students will submit questions to the scientists and also submit mission designs, as well as essays and drawings hypothesizing technological advancements that could permit colonization of the planet, to the web sites. Especially with the LPI Alpha students this could be done in conjunction with other Mars Mission planning activities that have previously developed by the institute. With the Mars Millennium sites, the material would be tested in a fashion more closely resembling what the final interactive web-based class

would be like. Student questions and the scientists' answers will be compiled and evaluated along with student submitted missions.

The Institute will also host a summer teachers' workshop, Liftoff, at the LPI. These educators, a selection of master middle and high school astronomy teachers, will be studying the planet Mars for one week at the Institute. They will as a part of their studies be asked to preview and comment on the material. LPI also has a group of former Liftoff teachers who are interesting in evaluating new products, they will be asked to review this curriculum. Hopefully, by next summer, these two web sites will be one part of a larger curriculum including Mars of the Past, Mars of the Present, and Mars of the Future.

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